MICE Beamline Magnet Drawings

Tom Roberts, Illinois Institute of Technology
November 28, 2003

Abstract

The design of the MICE beamline is still being revised. To further that effort, several datasheets for magnets at RAL have been obtained, and scans of them are included here for reference.

Bending Magnets

The Bending magnets available are Type I NIMROD Dipoles, as pictured at left. Images of datasheets are given at the end of this document. Note these magnets can be shimmed to have a larger vertical aperture.

Quadrupole Magnets

There are two types of quadrupoles being considered for the MICE beamline. For the pion triplet we have found three Type Q4 quadrupoles (images of datasheets are given at the end of this document).

For the muon triplets, we have found the pieces for 7 full quadrupoles plus one additional half-quadrupole of type QC from DESY (these are on site at RAL). Images of datasheets are given at the end of this document.

Decay Solenoid

We have tentatively located a decay solenoid at the Paul Scherer Institute. At present we have no drawings of it, but have drawings of a similar superconducting solenoid. The solenoid we expect to use is 5 meters long, but the drawing is of a solenoid 8.3 meters long. We believe that the solenoid we will use is similar in most respects to the drawing, except there are fewer modules in the center; the endcaps may also be somewhat different.

Note the drawing has been scanned in pieces, which I did not attempt to put together into one large drawing, as it would then not fit on the page.

Acknowledgements

I am indebted to Paul Drumm and Kevin Tilley for obtaining copies of these drawings.

BENDING MAGNETS

General

Types I, II and IV* magnets have a nominal vertical aperture of 6 in. Standard spacers are available to change this aperture to 4 in. or 8 in; other apertures can be arranged by manufacturing special spacers. When vacuum boxes are fitted the overall vertical apertures quoted are reduced by approx. 0.5 in.

Rectangular polepieces are fitted as standard; these can be replaced by tapered ones if required. The latter produce approx. 10% higher maximum field with some reduction in the uniform field width. Pole-piece shims can be fitted to trim the fringe field.

Types I and II magnets are of H form, providing a symmetrical field about the beam centre-line.

Type III magnets are of the poleless "window frame" type. They can be used in conjunction with electrostatic velocity separators not fitted with cross-field coils, or as general purpose bending magnets for low momentum beams. They have an 8 in. aperture through which a standard beam pipe can be located and are normally mounted for vertical plane beam bending.

Type IV magnets are C shaped for use where the beam layout restricts the space available for the magnet or when the yoke of an H magnet would lie in the beam path. The design parameters are the same as those of the Types I and II magnets.

Type V (spectrometer) magnets are also C shaped, allowing a number of them to be assembled together to form a larger unit. Different coils are required for each configuration. Schemes 1, 2, 3 and 4 show the arrangements currently available. The nominal aperture of 6 in. can be altered by fitting specially manufactured spacers.

Using special stands and coil supports, Type I magnets can be mounted to give vertical bending for use as bubble chamber threshold magnets. Type III magnets can be specially mounted for horizontal bending.

All magnets are remotely controlled, watercooled and fitted with flow monitoring and over temperature trips. Spark discharge gaps with current limiting coils are provided to protect the windings during the rapid field collapse resulting from a sudden power failure.

---

* See Note on page 1-2.

BENDING MAGNETS

Data

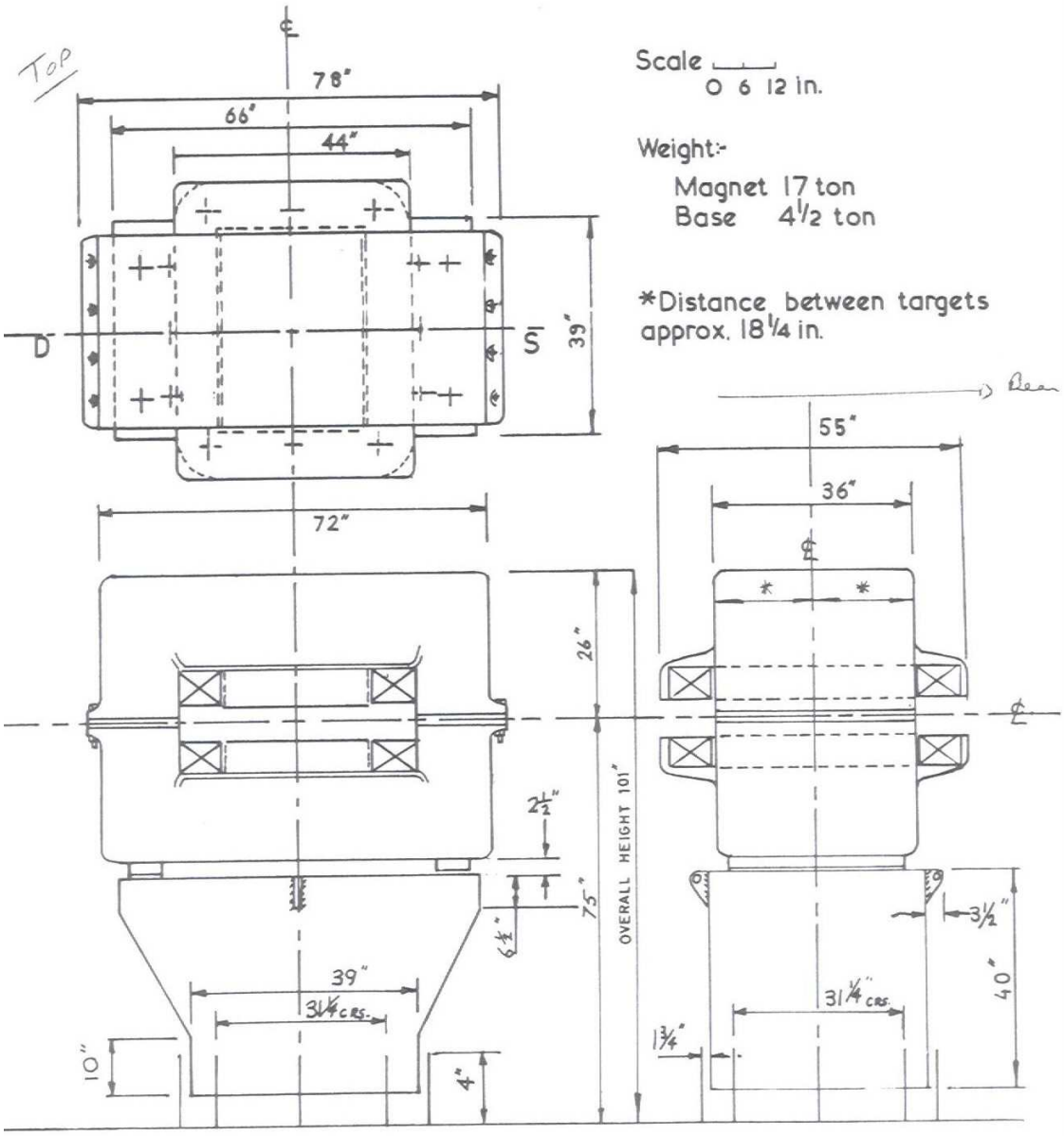
L = 55" = 1.375m (25/3/66) Actual (2.1m) L = 2.175m

TYPE NUMBER *	I	II	III	IV	V
Identification numbers	101-114	201-213	301-312	401-415	501-504
Total weight: stand (ton)	4.5	6	5 cwt.	3	
magnet (ton)	17	28.5	13 cwt.	26	50
Pole length (in.)	36	60	12	36	47
Pole width: straight (in.)	26	26	16	26	41
tapered (in.)	20	-	-	20	-
Normal gap height (in.)	6	6	8	6	6
Effective field length at normal gap (cm)	103.8	166.9	39.8	104.4	117.2
Normal maximum applied voltage (V)	190	190	95	190	190
Normal maximum current (A)	450	450	500	450	500
Calculated inductance (H)	1.2	3.3	0.012	1.5	2.0†
Normal maximum power dissipation (kW)	85.5	85.5	47.5	85.5	95.0
Overload capacity (A)	550	550	550	550	550
Spark gap breakdown voltage (V)	1000	1000	1000	1000	1000
Over voltage relay, norm. oper. voltage (V)	20	20	20	20	20
Number of turns	512	544	112	512	480
Thermal switches operate at (°C)	75	75	75	75	75
Resistance at 20°C (Ω)	0.37	0.361	0.144	0.37	0.321
Resistance at 54°C (Ω)	0.438	0.431	0.171	0.438	0.381
Interlock chain res. at 20°C (Ω)				2.7	
Normal field (at normal gap and normal current) (k.gauss)	15.5	15.8	4.2	16.5	14.56
Main power cable connection	$4x\frac{1}{2}$ in.	$4x\frac{1}{2}$ in.	$4x\frac{1}{2}$ in.	$4x\frac{1}{2}$ in.	$4x\frac{1}{2}$ in.
Cooling water flow rate (gal/min)	6.5	6.5	3.6	6.5	7.2
Pressure drop (lb/in^2)	-	50	-	65	-
Maximum permissable pressure (lb/in^2)	150	150	150	150	200
Flow switches operate at (gal/min)	5.5	5.5	2.6	5.5	6.2
Water fitting connection:					
inlet (B.S.P.)	$\frac{3}{4}$ in.	$\frac{1}{2}$ in.	$\frac{1}{2}$ in.	$\frac{3}{4}$ in.	1 in.
outlet (B.S.P.)	$\frac{1}{2}$ in.	$\frac{1}{2}$ in.	$\frac{1}{2}$ in.	$\frac{1}{2}$ in.	1 in.
Conductor Dimensions:					
outside (in.)	0.45x0.45	0.53x0.53	0.277x 0.221	0.45x0.45	0.51x0.51
inside (in.)	0.23x0.23	0.25x0.25	0.165x 0.109	0.23x0.23	0.25x0.25

† Scheme: I 2.0
II 4.0
III 4.0
IV 8.0

* NOTE: Roman numerals are used throughout this section. In practice Arabic numerals are often used to denote the different types.

TYPE I BENDING MAGNET AND BASE

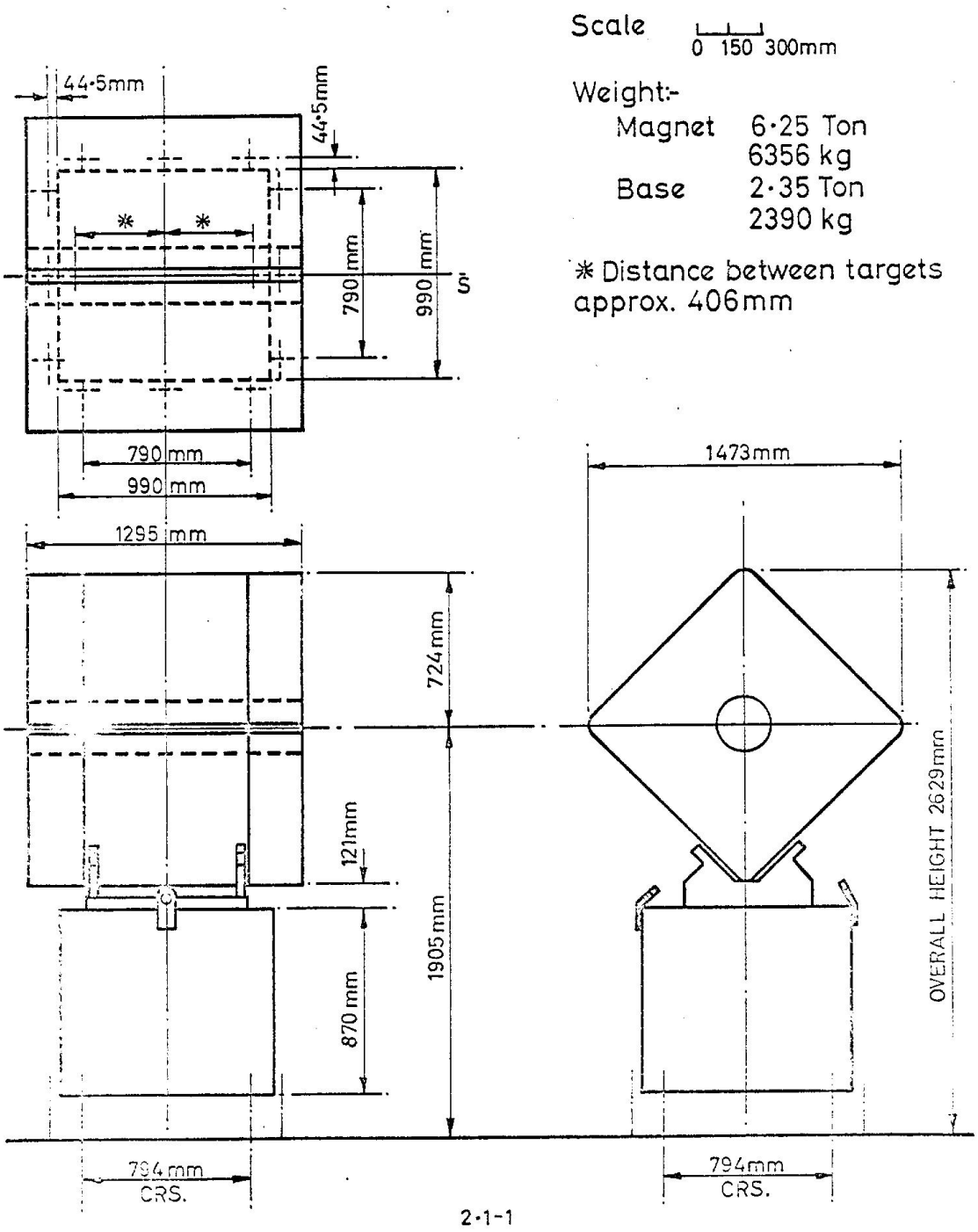


QUADRUPOLE MAGNETS

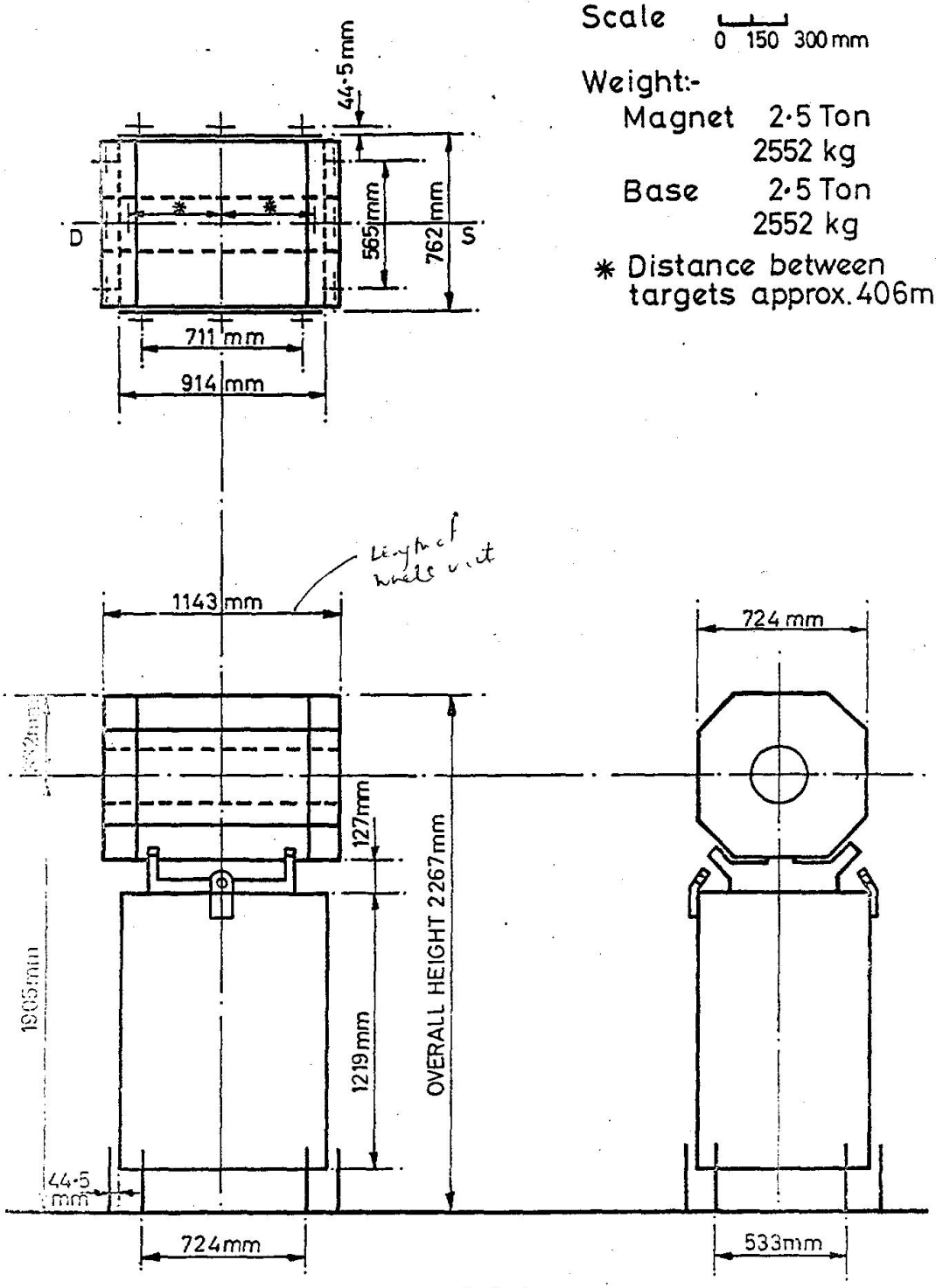
Actual (Tosca) L = 1.295m Actual (Tosca) L = 1.143m Data (1/74)

Type Numbers	1	2	3	4	5	6	7	8	9
Identification Numbers	Q101 to Q116	Q201 to Q230	Q301 to Q310	Q401 to Q425	Q507 to Q513	Q601 to Q603	Q701 to Q706	Q801 to Q806	Q901
Magnet Weight (Ton)	6.25	2.25	1.05	2.5	2.2	1.25		2.2	8.5
(Kg)	6356	2288	1068	2552	2237	1271		2237	8644
Stand Weight (Ton)	2.35	2.35	2.25	2.5	2.25	-	-	2.25	-
(Kg)	2390	2390	2288	2552	2288	-	-	2288	-
Normal Gradient at Max. Current (T/M)	11.7	10.3	10.3	9.68	10.0	10.0	12.50	10.0	
Normal Aperture (m.m.)	203	203	203	203	203	203	165	200	203
Effective Field Length at Normal Gap (m.m.)	8636	4775	4600	8534		11990	279		
Normal Max. Current (A)	500	500	1000	1000	1000	1000		750	500
Overload Capacity (A)	625	625	1250	1250	1250	1250		850	625
Normal Max. Power Dissipation (kW)	50	50	100	100	200	100	50		50
Normal Max. Voltage at Max. Current (V)	100	100	100	100	200	100		200	100
Calculated Inductance (mH)	160	78	19	120	32	10.3			
Number of Turns per Pole	119	111	54	43	57	49		57	129
Thermal Switch Operates at (°C)	85	85	85	85	85	85		85	
Winding Resistance at 20°C (Ω)	0.17	0.17	0.087	0.087		0.09		0.21	
Winding Resistance at 60°C (Ω)	0.19	0.19	0.096	0.096		0.106		0.245	
Cooling Water (Gal/Min)	4.5	4.5	8	8	16	8		12	
Flow Rate (m^3/sec)	3.4x 10^{-4}	3.4x 10^{-4}	6.8x 10^{-4}	6.8x 10^{-4}	13.6x 10^{-4}	6.8x 10^{-4}		10.2x 10^{-4}	
Max. Permissible (lb/in^2)	150	150	150	150	150	150	150	150	150
Pressure (N/m^2)	218x 10^{-4}	218x 10^{-4}	218x 10^{-4}	218x 10^{-4}	218x 10^{-4}	218x 10^{-4}	218x 10^{-4}	218x 10^{-4}	218x 10^{-4}
ure Drop (lb/in^2)	60					60		60	
(N/m^2)	84x 10^{-4}					87x 10^{-4}		87x 10^{-4}	

TYPE 1 QUADRUPOLE MAGNET AND BASE



TYPE 4 QUADRUPOLE MAGNET AND BASE



2·4 -1

QUADRUPOLES

Data

(5/68)

Type Numbers (See Note on P. 2-2)	Ib	Ic	II	III	IV	V	Va	VI	VIa
Identification Numbers	Q101 to Q116	Q101 to Q116	Q201 to Q230	Q301 to Q310	Q401 to Q420	Q501 to Q506		Q601	Q602, Q603
Total Weight:-									
Magnet (ton)	6.25	6.25	2.25	1.05	2.5	2.2	2.2	1.25	1.25
Stand (ton)	2.35	2.35	2.35	2.25	2.5	0.25	0.25		
Pole Length	30in.	30in.	15in.	15in.	30in.	750mm		15in.	15in.
Pole Width (Straight)	5.5in.	5.5in.	5.5in.	5.5in.	5.5in.	140mm		5.5in.	5.5in.
Normal Gradient at Normal Current (gauss/cm)	1170	1170	1030	1030	968	1000	1000	1000	1000
Normal Aperture	8in.	8in.	8in.	8in.	8in.	200mm	8in.	8in.	8in.
Effective Field Length at Normal Gap	34.0in.	34.0in.	18.8in.	18.5in.	33.6in.	1200 mm		47.2in.	
Normal Max. Voltage (V)	100	100	100	100	100	184		106	106
Normal Max. Current (A)	500	500	500	1000	1000	750		1000	1000
Overload Capacity (A)						850			
Calculated Inductance (mH)	160	160	78	19	120	32		10.3	10.3
Normal Max. Power Dissipation (mW)	50	50	50	100	100	138		106	106
Spark Gap Breakdown Voltage (V)	1000	1000	1000	1000	1000	1000	1000	1000	1000
Over Volts Relay at Norm. Operating Volts (V)	20	20	20	20	20	20	20	20	20
Number of Turns per Coil	121	121	111	54	43	57		49	
Thermal Switch operates at (°C)	75	75	75	75	75	75	80	75	80
Resistance at 20°C(Ω)	0.17	0.17	0.17	0.087	0.087	0.21		0.09	0.09
Resistance at 60°C(Ω)	0.19	0.19	0.19	0.096	0.096	0.245		0.106	0.106
Interlock Chain Resistance at 20°C(Ω)	1.54	1.54							
Main Power Cable Connection (BSF)	4x½in.	4x½in.	4x½in.	8x½in.	8x½in.	8x½in.		8x½in.	8x½in.
Cooling Water Flow Rate (gal/min)	4.5	4.5	4.5	8	8	12	12	8	8
Max. Permissible Pressure (lb/in²)	150	150	150	150	150	150	150	150	150
Pressure Drop (lb/in²)	60	60				60		60	60
Flow Switch operates at (gal/min)	3.5	3.5	3.5	6.5	6.5	9	9	6.5	6.5
Water Fitting Connection:- Inlet (O.D.)	½in.	½in.	¼in. BSP	½in. BSP	½in. BSP	1in.	1in.	1in.	1in.
Outlet (O.D.)	½in.	½in.	¼in. BSP	½in. BSP	½in. BSP	1in.	1in.	1in.	1in.
Conductor Dims.:- Outside (mm)	12.7x 12.7	12.7x 12.2	0.397x 0.397	0.38x 0.38	0.45x 0.45	7.5x 7.5		0.35x 0.35	
Inside (mm)	5.6x5.6	5.6 dia.	0.21x 0.21	0.21x 0.21	0.22x 0.22	3.8x3.8		0.17x 0.17	

DESY-Strahlführungsmagnete

Blatt: K 4

Datum: 1.4.66

Auskunft: K. Holm
H. Wümpelmann

QUADRUPOL-MAGNET TYP QC (Q35)

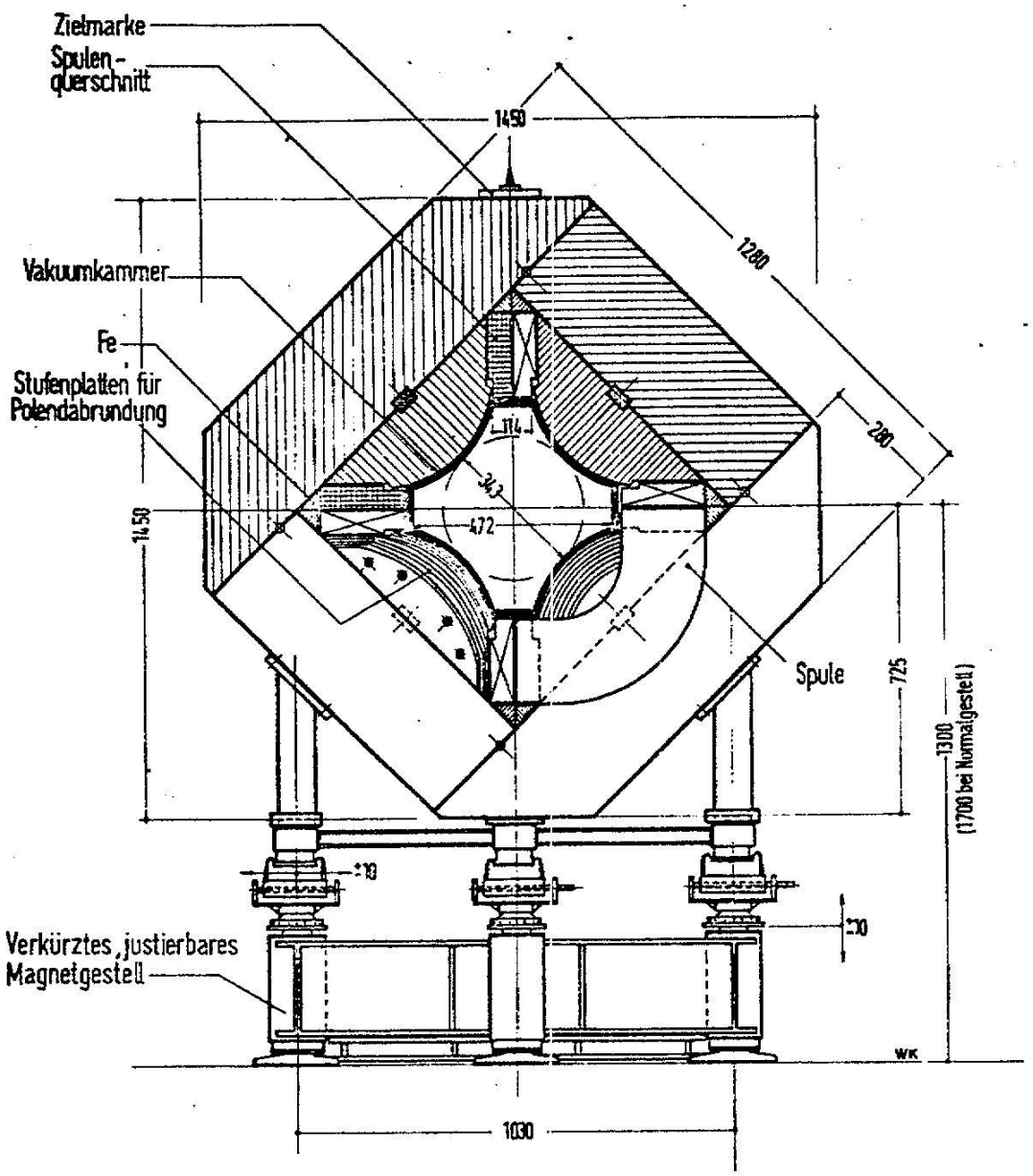
Harry. for your info. 250MeV/c requires 310Amps 15.1 KW. Gordon

Technische Daten

Vorhandene Anzahl		2	
Magnetgewicht		9	t
Gesamtlänge zwischen den Vakuumkammerflanschen		1170	mm
nutzbare Apertur in der Vakuumkammer	Kreis	343$^{\phi}$	mm — see diagram
	Rechteck	~~114·472~~	~~mm^2~~
Polabstand		356,38	mm
Polhyperbelendpunkt	x =	252	mm
	z =	63	mm
Polendabrundung unter 45°	$r^2 \cdot s$ =	$2 \cdot 126^2 \cdot 266$	mm^3
max. Stromstärke		1500	A
Feldgradient bei 1500 A		0,81	Kr/cm
Leistungsverbrauch bei 1500 A		400	KW
Gesamtwiderstand bei 20° C		0,158	Ω
integrierte magnetische Länge		660	mm
Zeitkonstante L/R (berechnet für 50°C)		0,68	sec
Windungszahl pro Pol		76	
mittlere Windungslänge		2530	mm
Leiterquerschnitt	Quadrat	11·11	mm^2
	mit Loch	6,5$^{\phi}$	mm
Zahl der Kühlkreise pro (per) Spule		8	
Kühlwassermenge bei 1500 A und ΔT = 40°C		135	l/min
erfordl. Differenzdruck für 135 l/min		4,5	at

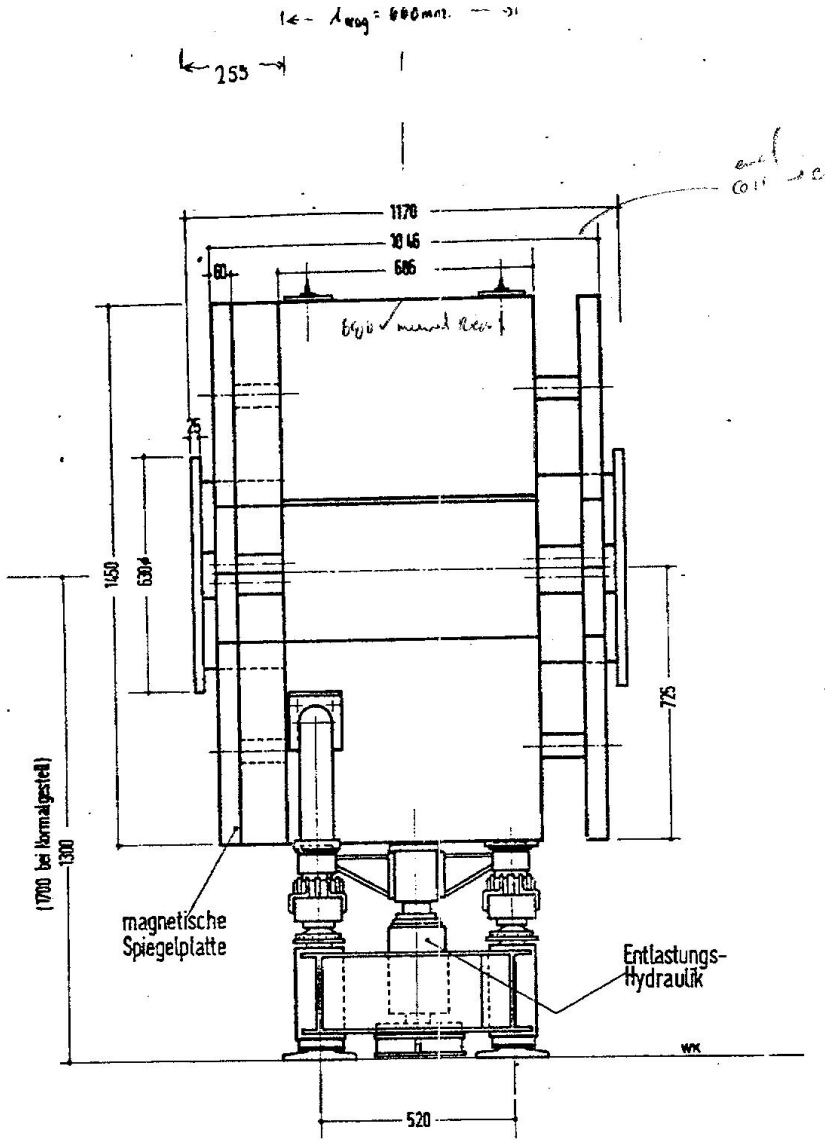
0.81 kG/cm ⇒ 8.17 T m^{-1}

Je 2 halbe Quadrupole lassen sich zu einem vollen Quadrupol QC zusammensetzen.



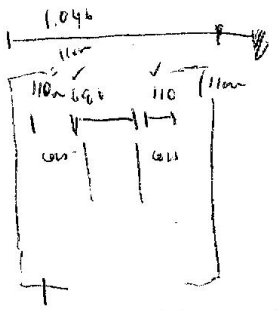
Querschnitt
Quadrupol-Magnet Typ: QC

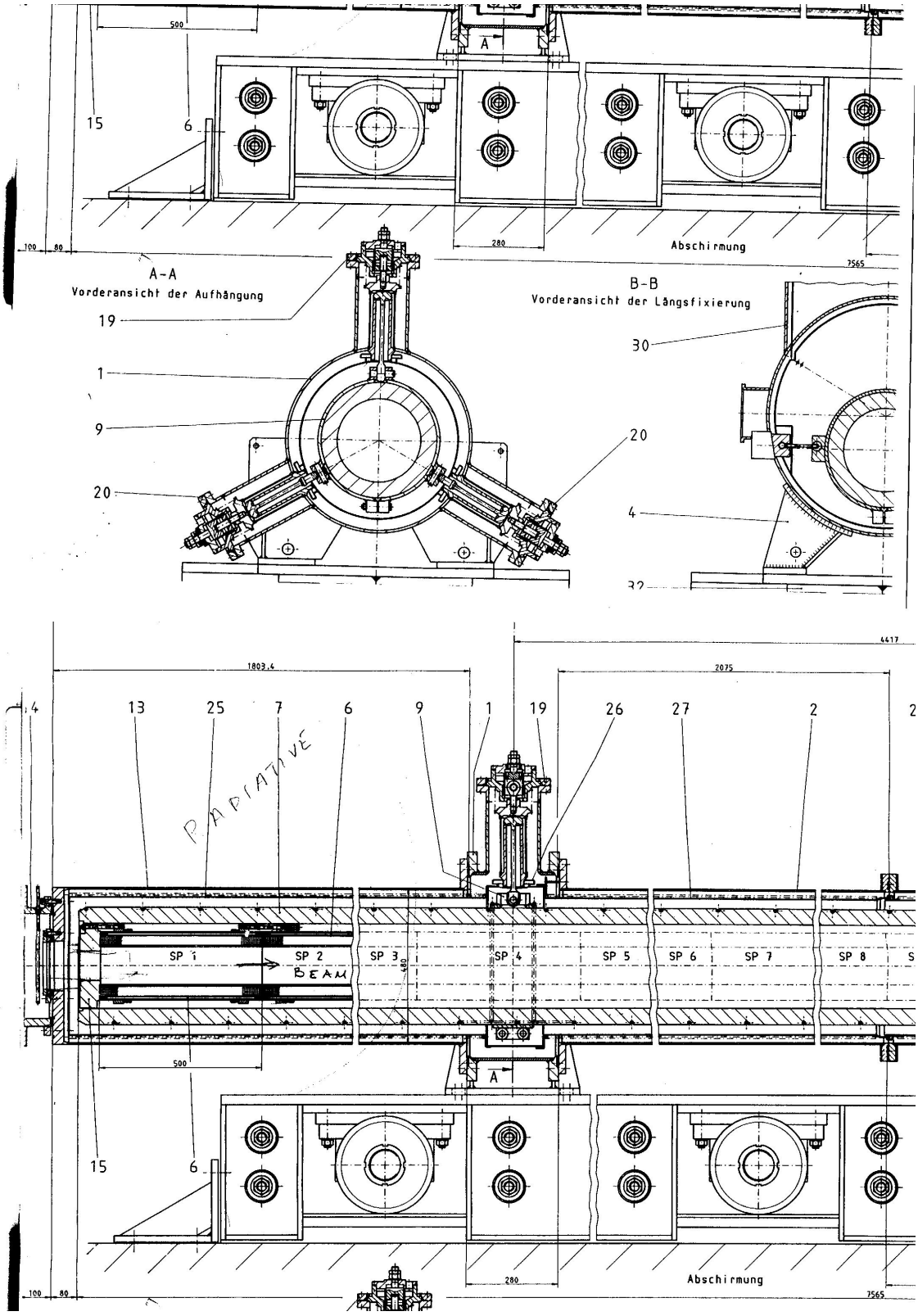
DESY-Strahlführungsmagnete
Blatt: K4.1 Seite 1
Datum: 9.2.66
Auskunft: H. Wümpelmann

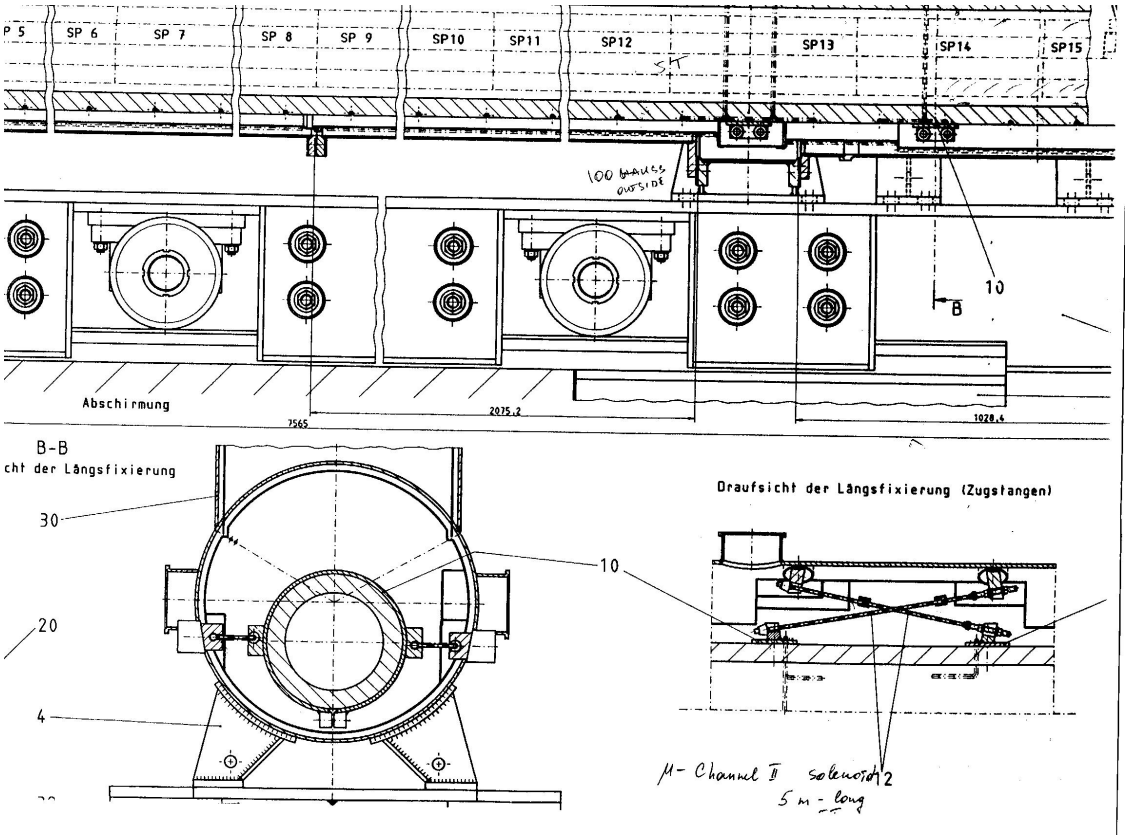


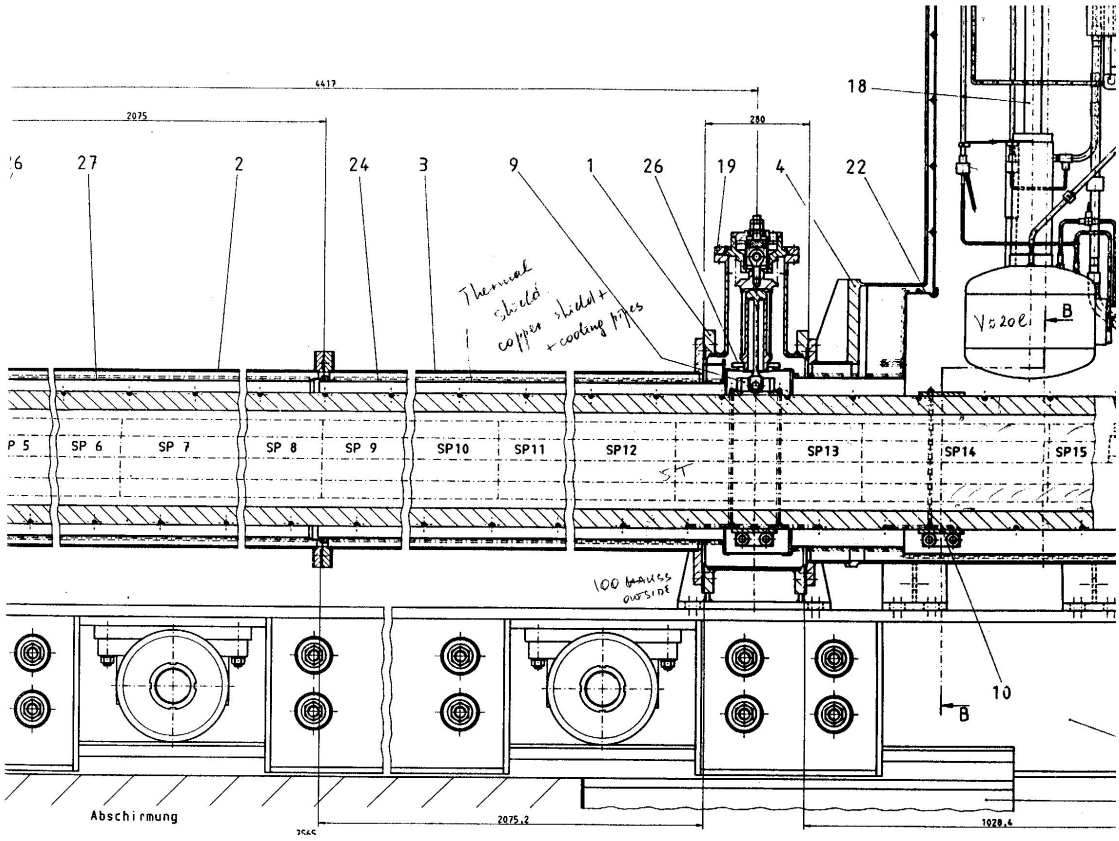
Seitenansicht
Quadrupol-Magnet Typ: QC

DESY-Strahlführungsmagnete
Blatt: K 4.1 Seite 2
Datum: 9.2.66
Auskunft: H. Wümpelmann




A-A
Vorderansicht der Aufhängung
B-B
Vorderansicht der Längsfixierung
Abschirmung
Abschirmung
SP 1
SP 2
SP 3
SP 4
SP 5
SP 6
SP 7
SP 8
BEAM
PRIMITIVE


SP 5
SP 6
SP 7
SP 8
SP 9
SP10
SP11
SP12
SP13
SP14
SP15
100 outside
10
B
Abschirmung
7565
2075,2
1028,4
B-B
cht der Längsfixierung
30
20
4
10
Draufsicht der Längsfixierung (Zugstangen)
12
5 m - long


4417
2075
280
18
6
27
2
24
3
9
1
26
19
4
22
Thermal shield copper shield + cooling pipes
V≈20ℓ
B
P 5
SP 6
SP 7
SP 8
SP 9
SP10
SP11
SP12
SP13
SP14
SP15
100 Gauss outside
10
B
Abschirmung
2075,2
1028,4